

(NASA-CR-121320) MOON-TO-EARTH ANTENNA LOOK
ANGLES FOR CONTINUOUS TV COVERAGE DURING LRV
TRAVERSES (Bellcomm, Inc.) 3 p

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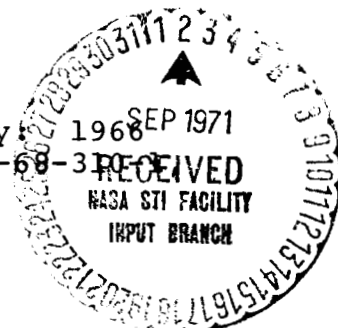
MEMORANDUM FOR FILE

One approach to continuous TV coverage during LRV traverses would be the use of a medium gain antenna which does not require steering, such as the ALSEP antenna with a $\pm 8.5^\circ$ beamwidth. (This will probably require the use of the 210' dish for the earth receiver.) It would be convenient if this ALSEP antenna could be pointed along the local vertical so that heading changes of the LRV would have only a small effect on received signal strength. The question, therefore, is what is the vertical angle to the earth, say, measured from the zenith; this is called the zenith distance.

This vertical angle does depend on the coordinates of the particular landing site. These are shown in Table I for the Apollo 16 and 17 sites; the Apollo 15 and the alternate site for Apollo 17 are also shown for reference. The entry labeled Radial is the total angle for the given latitude and longitude, and it is seen to be 17° and 14° for Apollo 16 and 17, respectively.

The vertical angle to the earth also depends on the geometric libration of the moon. This motion follows the lunar month and can amount to $\pm 8^\circ$ in both latitude and longitude.* This motion can be visualized as follows. The line connecting the center of the earth to the center of the moon will form a locus on the surface of the moon. This locus is an elliptical lissajous figure which varies from a straight line to almost a circle. It can change the antenna angle to the earth by as much as one degree a day.

*"A Compendium of the Moon's Motion and Geometry: 1968 through 1985", by J. O. Cappellari, Jr., Bellcomm TR-68-310, January 9, 1968.





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A computer program was written (by Mrs. S. C. Wynn) to give the earth zenith distance as a function of the local sun angle for the several launch months. The problem, then, is to determine the minimum sun angle at the start of the first LRV traverse and the maximum sun angle at the end of the last LRV traverse. For the purposes of this study a minimum sun angle of 5° at landing was assumed. With a minimum check-out time of four hours and a sun rate of $0.5^\circ/\text{hr}$, the minimum sun angle of 7° was used for the start of the first traverse. With a maximum landing sun angle of 23° and a maximum stay time of 68 hours (less six hours for liftoff preparation) the maximum sun angle of 54° was used for end of the last traverse. The vertical angle of the earth for these extreme sun angles is listed in the last two columns of Table I.

An examination of Table I reveals that the maximum value of the vertical angle of the earth (as measured from zenith) occurs at the end of the LRV mission. In all cases this angle is less than the radial angle of the landing site. This should be considered as serendipity as we did not anticipate such a favorable relationship between the coordinates of the landing site and the phase of the libration cycle.

While the libration of the moon gives an earth vertical angle a few degrees less than the radial angle of the site, the reduction is insufficient. The vertical angle for Apollo 16 is 14° and for Apollo 17, 12° . These values exceed the 8.5° beam-width of the ALSEP antenna. Therefore, a simple vertical orientation of this antenna does not solve the problem of continuous TV coverage. An obvious modification of this approach would be to manually aim the antenna towards the earth at the start of a traverse leg to account for the gross heading of the LRV during this portion of the traverse. This modified approach may give satisfactory results unless the LRV has to undergo drastic heading changes to avoid local obstacles.

In conclusion, it should be noted that while the medium gain antenna approach has the virtue of simplicity, it is inherently a marginal system. At best it can handle only $\pm 8.5^\circ$ pitch and roll attitude changes. Even this range is reduced by any general lunar slope or by traverses along the side of a hill. When we further consider the non-zenith earth angles and the cross-coupling effects of LRV heading changes, the "continuous" TV coverage may prove to have a very small duty cycle.

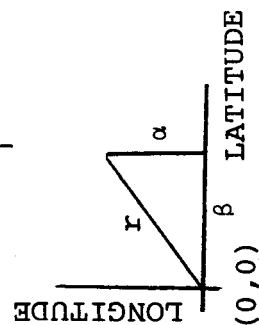
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Attachment
Table I

TABLE I
MOON-TO-EARTH ZENITH DISTANCE ANTENNA ANGLES

NAME	APOLLO #	LANDING DATE	LATITUDE α	LONGITUDE β	RADIAL r	ZENITH DISTANCE	
						INITIAL	FINAL
Hadley	15	7/30/71	25.2°	2.9°	25.4°	20.7°	23.7°
Descartes	16	3/22/72	-8.8°	14.6°	17.0°	9.8°	14.3°
Alphonsus	17	12/14/72	-13.3°	-4.2°	13.9°	7.0°	12.3°
Davy Rille	17 alt	12/14/72	-10.9	-6.0°	12.4°	4.6°	6.8°



$$\cos r = \cos \alpha \cos \beta$$